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Magnetic force microscopy investigation of domain structure and magnetic recording patterns in high-coercive garnet films with low Curie temperature

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Authors present the investigation of domain structures and thermomagnetic recording patterns in iron garnet thin films by magnetic force microscopy. Iron garnet films with low Curie temperature and high coercivity were designed for recording process. Magnetic pattern of PC floppy disc was recorded in iron garnet film by contact printing method. Topography and magnetic structure of floppy disc and iron garnet film before and after thermomagnetic recording process are presented. Accuracy of thermomagnetic recording and parameters, which are influence on it, are discussed.

Iron garnet films are very perspective materials for thermomagnetic recording applications. For these purposes, iron garnet films with low Curie temperature and high coercivity are designed. The films can be used for contact printing of high density and weak residual magnetization records in criminalistics and, potentially, for trapping of ultra cold neutral atoms. Authors' goal was the investigation of features of domain structure after thermomagnetic recording including its resolution, in garnet thin film by precise magnetic force microscopy technique The films of nominal composition $(SmLuBi)_3(FeGaAlSc)_5O_{12}$ were synthesized by liquid phase epitaxy on single-crystal substrates of gadolinium gallium garnet (GGG) with (111) crystallographic orientation. The increasing of mismatch between crystalline lattices of film and substrate and Sm incorporation in composition lead to increase of the film coercivity. Dilution of Al, Ga and Sc decreases the film Curie temperature. The film with thickness of 2.5 μm, Curie temperature of 70^{o}C, coercivity of 62 Oe, saturation field of 280 Oe and the positive mismatch of the film-substrate lattice constants of 0.087 A and surface roughness of 5 nm were selected for experiments. The magnetic domain structure before recording with average period of 9 μm and topography of film are shown in Figure 1.

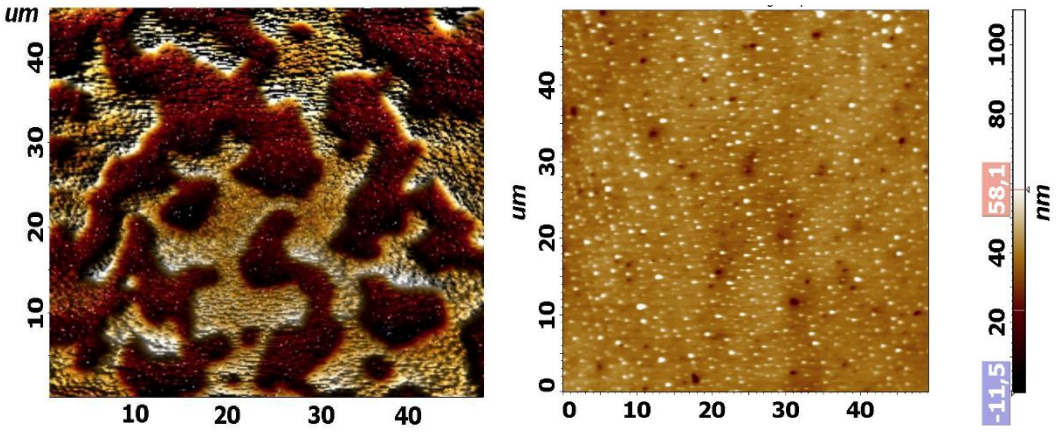

Figure 1. Domain structure (left) and topography (right) of iron garnet film. Images were obtained from the same area.

Thermomagnetic recording of PC floppy disc magnetic pattern in iron garnet film was performed by heating both of them with direct contact of their surfaces up to 100^0 C. Then floppy disc and the film were cooling in contact with each other down to ambient temperature.

Magnetic pattern of floppy disc is shown in Figure 2a. In thermomagnetic recording process film's domain structure is changed by applied magnetic field of floppy disc. As a result, the film domain structure repeats floppy disc's magnetic pattern (Figure 2b). Domain structure of the film after recording depends not only on floppy disc's magnetic field but also on film's surface features and defects in films. Recorded domain structure has rough borders because of the dislocations network was formed in the growth process (due to the high film-substrate lattice constants mismatch). Actually recording process goes via segments that free from dislocations. Formed dislocations network limits the size of segments to 1-3 μm [1,2]. The determined deviation of the shape of recorded boundaries from a straight lines is ± 0.4 μm.

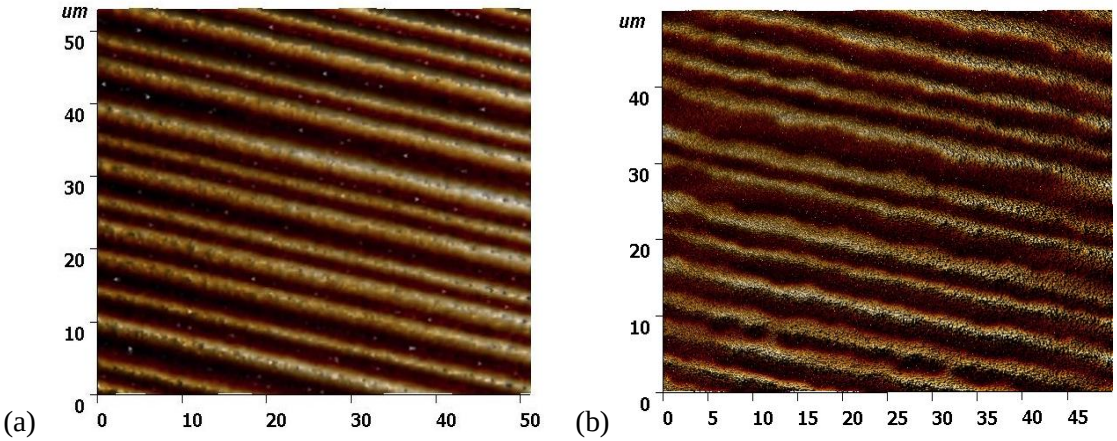

Figure 2. (a) Magnetic pattern of PC floppy disc and (b) contact printed recording in iron garnet film.

Floppy disc does not have domain structure in some areas. In this case after recording the film shows its own domain structure with average period of 6.4 μm. Border between two types of domain structure of the film is showed in Figure 3.

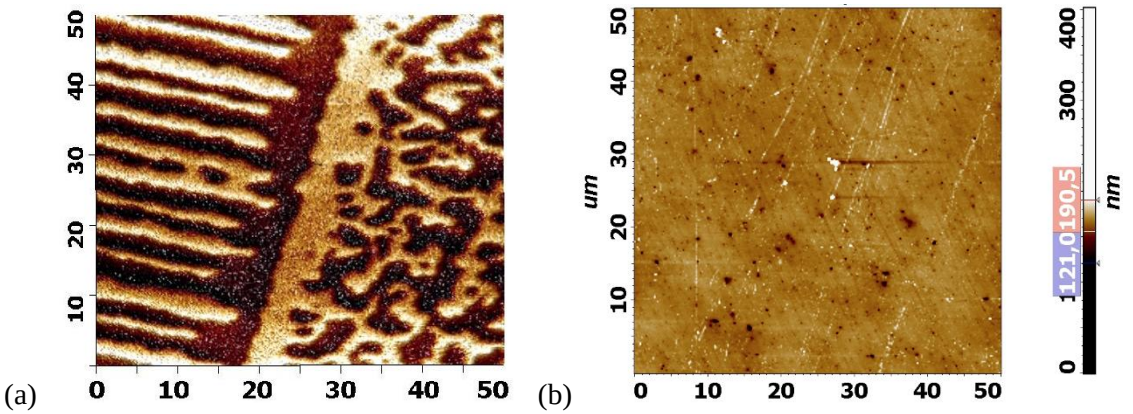

Figure 3. (a) Border between two types of domain structure in iron garnet film (recorded area left and thin film's own area right).
(b) Topography of the same area.

As a result of the investigation of thermomagnetic recording of PC floppy disc magnetic pattern in liquid phase epitaxial iron garnet film with high coercivity and low Curie temperature, it is was shown that the resolution of any recording is limited by the network of defects in the crystal structure and the morphology of the surface created by them. It is expected that the recording resolution will correlate with the film-substrate lattice constants mismatch.

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